C B Plowright
to
Mr Marshall.
2nd Feb 28/8
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British Heteroecismal Uredines
by
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On the Life-History of certain British Heterœcismal Uredines. (The Ranunculi Æcidia and Puccinia Schœleriana.)

By

Charles B. Plowright.

In the following communication, the life-histories of five × species of Uredines which during the past three years have been investigated are detailed, together with an enumeration of the experimental cultures performed in connexion therewith, by which it will be seen that the conclusions have not been hurriedly arrived at. It may be thought that many of these cultures are needless repetitions, but I have found myself compelled to differ in certain points with the eminent Continental botanists who have made this subject their special study, and to whom, indeed, we owe all the information we at present have concerning it. It will be seen that these differences are mainly connected with the host plants upon which the various Uredines in question occur. It is hoped that my eminent confrères will recognise the fact that my investigations have not been made in any spirit of captious criticism, but rather with the object of verifying and amplifying the discoveries they have already made. Hence when any statement of theirs has been found to accord with my own results, this particular culture has not been repeated many times. For example, with Uromyces dactylidis twenty-seven experiments were made altogether, but of these only five were confirmatory of Schröter's statement as to its Æcidium occurring upon Ranunculus bulbosus, for the simple reason that Schröter's statement on this point is correct, and it would have been a

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mere waste of time to have proved what is already known to be true. The other twenty cultures were made upon other host plants, and were mostly repetitions made over and over again before I felt myself justified in differing from him.

Experiments 1 to 100 were made in 1882.
„ 101 „ 244 „ „ 1883.
„ 245 „ 426 „ „ 1884.

The Ranunculi Æcidia.

History of the Subject.—The various members of the Ranunculus family are peculiarly liable, as Schröter[1] has pointed out, to be affected with the æcidiospores of various Uredines. In fact in this country no less than eleven species have Æcidia occurring more or less frequently upon them, whereas only four species have either teleutospores or uredospores affecting them. The æcidial host plants belonging to the Ranunculaceæ in this country are Clematis vitalba, L.; Thalictrum alpinum, L.; flavum, L.; Anemone nemorosa, L.; ranunculoides, L.; Ranunculus acris, L.; repens, L.; bulbosus, L.; ficaria, L.; Caltha palustris, L., and Aquilegia vulgaris, L.; while teleutospores and uredospores only occur on Thalictrum flavum, L.; Anemone nemorosa, L.; Ranunculus ficaria, L.; and Caltha palustris, L.

The author above quoted has shown that many of these Æcidia are heterœcismal. He pointed out that those writers who, like Fuckel[2] and Cooke,[3] have affiliated the very common Æcidium upon R. ficaria with the Uromyces, which also occurs upon this plant, were wrong in so doing; that these two fungi are distinct species, having separate and altogether unlike life-histories, and that their occurrence upon the same host plant is a mere accidental circumstance. He further showed that the Æcidium in question is really connected with a Uromyces which affects the various Poæ. This he did by a series of artificial cultures. He was led to try these experiments from his previously obtained knowledge of the life-history of Uromyces dactylidis, which he found had its uredo and teleutospores upon Dactylis glomerata while its æcidiospores occur upon Ranunculus bulbosus. The results obtained by Schröter were (1) that Uromyces dactylidis, Otth, is produced from a Uredo upon Dactylis possessing capitate paraphyses having its Æcidia upon Ranunculus bulbosus and repens. (2) That the Uredo without paraphyses and its Uromyces upon Poa nemoralis are connected with the Æcidium upon R. ficaria. Winter, in his latest work,[1] following Schröter, thus gives the relationships of these species.

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[1] Schröter, 'Cohn's Beiträge zur Biologie der Pflanzen,' vol. iii, Heft 1, p. 59.

[2] Fuckel, 'Symbol. Mycol.,' p. 64.

[3] Cooke, 'Uromyces in Grevillea,' vol. vii, p. 136.

Uromyces dactylidis, Otth.

Æcidiospores on.	Teleutospores on.
Ranunculus acris, L.	Arrhenatherum elatius, M. and K.
„ polyanthemos, L.	Poa nemoralis, L.
„ repens, L.	Dactylis glomerata, L.
„ bulbosus, L.	Festuca elatior, L.

Uromyces poa Rabh.

Æcidiospores on.	Teleutospores on.
Ranunculus ficaria, L.	Poa nemoralis, L.
	„ pratensis, L.

Cornu[2] has, however, still more recently shown that Ranunculus repens is the host plant of the Æcidium of Puccinia arundinacea, D. C. He further considers that P. graminis, Pers., occurs upon Phragmitis communis not unfrequently, when it is characterised amongst other things by forming long black lines on the stem.

Rostrup[3] regards the Æcidium on Ranunculus repens as being due to Uromyces poæ, Rbh.

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[1] Winter, 'Rabenhorst's Kryptogamen Flora,' vol. i, p. 162.

[2] Cornu, 'Comptes Rendus,' 26 Juin, 1882.

[3] I regret having mislaid the communication which Mr. Rostrup sent me. It was a list of Danish fungi, in which the æcidiospores of Uromyces poæ were given as occurring upon Ranunculus ficaria and repens.

Personal Investigations.—The above being the state of our information concerning the affinities of the Ranunculi Æcidia, the following series of experimental cultures have been made in the hope of definitely clearing up the matter. These were commenced in 1882 and continued through 1883 and 84.

Contradictory as the above views appear to be in many points, yet it will be seen that they are none the less in the main correct.

In order to render this communication the more lucid at the expense of increasing its length to some extent, each species will be treated separately, and have appended to it a tabular statement of the cultures made respecting it.

Uromyces poæ, Rbh.—This Uromyces occurs in England very abundantly upon Poa trivialis, L., and P. pratensis, L. I have not met with it upon any other species of Poa nor upon any other grass. Of course it may occur upon other grasses, but I have never found it, nor have I been able to produce it upon any other. As Schröter has shown, its Æcidium is very abundant from February to May upon Ranunculus ficaria. But not only is R. ficaria its host, but also R. repens. This latter fact was suggested to me before I knew of Rostrup's views from the profusion with which the above-named Poæ were attacked by the Uromyces in localities in which R. ficaria did not occur, and in which R. repens did. A series of seven experiments were made, however, by placing the spores of Æcidium Ranunculi repentis upon Dactylis glomerata (Expts. 29, 30, 119, 122, 131, 153, 154) before Schröter and Winter's statement that it is connected with Uromyces dactylidis was definitely rejected. The material employed in these experiments was not collected from a single locality; on the contrary, specimens were procured from several places near King's Lynn, and even from Shrewsbury, kindly sent to me by Mr. W. Phillips, F.L.S. Moreover, the Æcidium upon R. repens gave rise to no Uredo upon P. nemoralis (143) nor upon P. annua (155). Conversely the germinating spores of Uromyces dactylidis in five cultures upon

R. repens gave no result (118, 249, 254, 270, 290); we may therefore conclude that Uromyces dactylidis is not connected with the Æcidium upon R. repens.

On the other hand, the Æcidium on R. repens was found to produce the Uredo and Uromyces upon Poa trivialis (190, 322, 333). But here another difficulty confronted me, inasmuch as no less than in seven other cultures with the spores of the Æcidium on R. repens applied to P. trivialis and P. pratensis did I fail to obtain any result (120, 146, 147, 155, 191, 336, 370). It is all very well to say that one positive result is of more value than an indefinite number of negative results, but succeeding only in three out of ten cultures requires some satisfactory explanation. Those who have performed cultures with the Uredines know well enough how easy it is to fail from a variety of causes. I have failed more than once in infected wheat plants with Uredo linearis in which no question of specific identity is concerned. It is furthermore very easy to fail with cultures in which æcidiospores are employed as the infecting material, because, in the first place, the æcidial cup is full of spores, but only the few mature ones at its orifice will germinate at all; and in the second place, because even these ripe spores very rapidly lose their germinative power. Still these facts were well enough known to me, at any rate in my later cultures when I had also gained some knowledge of the minutiæ required for successfully manipulating with these bodies. As will be seen later, the explanation simply is that upon Ranunculus repens another Æcidium occurs (that of P. Magnusiana) which so closely resembles it in appearance, and in the form, size, and colour of its spores, that I am quite unable to tell the one from the other. I do not say that this cannot be done by others more skilled in the differentiation of uredine spore forms, but up to the present I have been unable to do so.

The Æcidium on R. ficaria gave no result on P. nemoralis (133, 296), nor upon Dactylis glomerata (297), but upon P. trivialis (295) it gave rise to the Uredo of Uromyces Poæ.

No. of Expt.	Infecting Material.	Plant Infected.	Date of	
			Infection.	1st Result.
190.	Æcidium Ranunculi repentis	Poa trivialis	19 June.	10 July.
322.	„ „	„ „	25 Apr.	14 May.
333.	„ „	„ „	9 May	20 May.
295.	„ Ranunculi ficariæ	„ „	9 Apr.	10 May.
29.	„ Ranunculi repentis	Dactylis glomerata	13 May	—
30.	„ „	„ „	13 May	—
119.	„ „	„ „	28 Apr.	—
122.	„ „	„ „	28 Apr.	—
131.	„ „	„ „	2 May	—
153.	„ „	„ „	31 May	—
154.	„ „	„ „	31 May	—
143.	„ „	Poa nemoralis	21 May	—
155.	„ „	„ trivialis and annua	1 June	—
118.	Uromyces dactylidis	Ranunculus repens	28 Apr.	—
249.	„ „	„ „	2 Feb.	—
254.	„ „	„ „	8 Feb.	—
270.	„ „	„ „	5 Mar.	—
290.	„ „	„ „	7 Apr.	—
120.	Æcidium Ranunculi repentis	Poa pratensis	28 Apr.	—
146.	„ „	„ „	21 May	—
147.	„ „	„ „	26 May	—
191.	„ „	„ trivialis	16 June	—
336.	„ „	„ „	9 May	—
370.	„ „	„ „	21 May	—
133.	„ Ranunculi ficariæ	„ nemoralis	2 May	—
296.	„ „	„ „	9 Apr.	—
297.	„ „	Dactylis glomerata	9 Apr.	—

Puccinia Magnusiana.—There are certainly two Pucciniæ which occur in this country upon one common reed (Phragmitis communis, Trin.), the one characterised by its teleutospores being born upon very long pedicels and its brown uredospores not being mixed with paraphyses. This is P. phragmitis, Schum = (P. arundinacea, D. C.). The other, P. Magnusiana, Körn, has its teleutospores with much shorter pedicels, and they often form long black lines running down the sheaths and stems of the affected plant. Its uredospores, moreover, are deep orange in colour, and always, as far as I know, mixed with paraphyses. This species has in this country hitherto generally been regarded as a variety of Puccinia graminis, Pers.

In a previous paper[1] I have shown that P. phragmitis has its æcidiospores upon Rumex conglomeratus, crispus, obtusifolius, hydrolapathum, and Rheum officinale (Expts. 140, 178, 179, 180, 181, 182, 183, 334), and conversely that the æcidiospores of Æc. rumicis thus produced, when placed upon Phragmitis, gave rise to the brown Uredo of P. phragmitis without paraphyses (148, 166, 172, 188, 189, 208, 209). This being the case, it occurred to me, after reading Cornu's [2] communication that it was just possible he might have confounded these two Pucciniæ, and that P. Magnusiana might have its Æcidium upon Ranunculus repens. This possibility was to me the more probable, because I had in 1882 fallen into a similar error, and I had then operated in the same manner as M. Cornu appears to have done, namely, by placing leaves and stems of the Phragmites upon the plant to be infected. Since 1882 all my cultures with these Pucciniæ have been made by germinating the teleutospores in a watch-glass, having previously separated them from the reed, and examining them microscopically to insure against error from the commingling of the spores of the two species. Now, it happened that after reading M. Cornu's paper I found, in the autumn of 1883, a long, straight ditch full of reeds upon which at both ends, for about twenty yards, the Phragmites were completely blackened by P. Magnusiana. This ditch was about a quarter of a mile in length, and the reeds which grew in the intervening part were quite free from the Puccinia. Neither did I observe anywhere in it a single pustule of P. phragmitis. In the spring of 1884 I from time to time visited this ditch and carefully examined the Rumices and Ranunculi growing on its banks, for I felt certain, from the localised profusion with which P. Magnusiana occurred, that I should meet with its Æcidium at both ends, but not in the central part. This surmise was found to be correct, and to confirm the conclusion I had already, from a series of experimental cultures, arrived at. At both ends of the ditch I found the Rumices free from Æcidia, but the plants of Ranunculus repens abundantly affected with Æcidia, while in the middle neither one or other of these plants had any Æcidium upon them. Germinating spores of P. Magnusiana were placed upon Ranunculus repens with the uniform result of giving rise to the Æcidium (315, 335, 358). It is obvious that if Ranunculus repens is the host plant to two specifically distinct Æcidia, the possibility of other Ranunculi also being hosts of one or other of them must be considered. P. Magnusiana was, therefore, applied to R. acris (360), R. ficaria (361), R. auricomus (359), but without any result. When, however, R. bulbosus was infected it always developed the Æcidium (393, 394, 395, 396, 397), hence P. Magnusiana has its Æcidium upon both R. repens and R. bulbosus. Conversely, the æcidiospores of P. Magnusiana which had been artificially produced upon R. repens (369) and R. bulbosus (422), were placed on Phragmitis, where in due time they gave rise to the orange Uredo with paraphyses. To make more sure, a part of the same spores from R. repens, which, when placed on Phragmitis (369) gave origin to the Uredo of P. Magnusiana, were applied to Poa trivialis (370), but they gave rise to no Uredo; and in like manner a part of the spores from the Æcidium R. bulbosus (423) were placed upon Dactylis glomerata, but they gave rise to no Uredo. The two Æcidia on R. repens were most carefully examined side by side, but no difference could be detected by me. As these two Æcidia occur in a state of nature, however, that of Uromyces poæ occurs rather earlier in the year than that of P. Magnusiana.

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[1] Plowright, "On the Life-History of the Dock Æcidium," 'Proc. Royal Soc.,' No. 228, 1883, pp. 47—49.

[2] Cornu, 'Comptes Rendus,' 26 June, 1882.

Puccinia phragmitis gave rise to no Æcidium on Ranunculus repens (137, 138), nor on R. ficaria (142), although the teleutospores were in active germination when employed.

But the subject is not even yet fully exhausted. The eminent Danish botanist, Mr. P. Nielsen, in 1879,[1] found that the Æcidium on Rumex acetosa was developed from P. phragmitis, and Winter[2] gives his adherence to this view. Now, Mr. Nielsen is a most careful and expert experimenter with the Uredines. I therefore performed the following experiment. A quantity of P. phragmitis was placed in water in a watch-glass, when it was found, by microscopical examination, that the spores were in active germination; one half was placed on a plant of Rumex acetosa (347), and the other half upon one of R. obtusifolius (346). The infected plants were both treated alike, but while in nine days the R. obtusifolius became affected with Æcidium rumicus, the R. acetosa remains to this date (Oct. 31st) free. This method of experimenting in duplicate is a very valuable one, and I have frequently employed it inasmuch as it lessens the possibility of error. P. phragmitis was also applied to R. acetosa (177), but without result, as was also the case when P. Magnusiana was employed (139, 179, 206, 323). Of course, these are only negative results, but it is at least remarkable that I should have had no difficulty in producing Æc. rumicis on the other Rumices, but always have failed with R. acetosa. It happens, however, that upon Phragmitis Professor Oudemans[3] has recorded the occurrence in Holland of P. straminis; and in the early part of the year 1882 Mr. Bloome sent me, from near Worthing, a Puccinia on reed, which I regarded at that time as being either P. straminis or P. sessilis, but, unfortunately, the specimen was not preserved by me. This being the case, it is possible that the Puccinia which Oudemans and myself have seen on reed may be a third species connected with the Æcidium on Rumex acetosa; and as it is of such an inconspicuous appearance, may have accidentally crept into Mr. Nielsen's cultures. This, of course, is a mere conjecture upon my part, which can only be confirmed by direct observations. Lastly, with regard to the belief that P. Magnusiana is only a form of P. graminis occurring upon reed, a duplicated experiment was performed in which P. Magnusiana, taken from the black lines on the stem, was placed upon Berberis vulgaris (362) and Ranunculus repens (358); on the former it gave no result, on the latter in ten days its Æcidium.

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[1] Rostrup, 'Heteroeciske Uredineer,' p. 10; 'Observations nouvelles sur les Urédinées à generations alternantes,' p. 3; 'Aftryk. af Oversigt over d. K. D. Vidensk. Selsk.,' Fordhandl, 1884.

[2] Winter, 'Rabenhorst's Kryptogamen Flora,' 1881, p. 222.

[3] Oudemans, 'Bijdrage over niew ontdekte Champignons voor de Flora van Nederland,' 1871, p. 22.

No. of Expt.	Infecting Material.		Plant Infected.		Date of	
					Infection.	1st Result.
315.	Puccinia	Magnusiana	Ranunculus	repens	24 Apr.	10 May.
335.	„	„	„	„	9 May	2 June.
358.	„	„	„	„	18 May	28 May.
393.	„	„	„	bulbosus	7 June	15 July.
394.	„	„	„	„	7 June	15 July.
395.	„	„	„	„	7 June	15 July.
396.	„	„	„	„	7 June	15 July.
397.	„	„	„	„	7 June	15 July.
34.	„	„	Rumex	conglomeratus	18 May	—
70.	„	„	„	„	15 June	—
81.	„	„	„	„	15 June	—
167.	„	„	„	„	5 June	—
72.	„	„	„	obtusifolius	15 June	—
169.	„	„	„	„	5 June	—
168.	„	„	„	crispus	5 June	—
171.	„	„	„	hydrolapathum	7 June	—
205.	„	„	„	„	28 June	—
184.	„	„	Rheum	officinale	12 June	—
187.	„	„	„	„	13 June	—

No. of Expt.	Infecting Material.	Plant Infected.	Date of Infection.	Date of 1st Result.
422.*	Æcidium Ranunculi bulbosi	Phragmitis communis	1 July	20 July.
423.*	„ „	Dactylis glomerata	1 July	—
369.*	„ Ranunculi repentis	Phragmitis communis	21 May	9 June.
370*	„ „	Poa trivialis	21 May	—

* From Puccinia Magnusiana.

No. of Expt.	Infecting Material.	Plant Infected.	Date of Infection.	Date of 1st Result.
140.	Puccinia phragmitis	Rumex crispus	16 May	27 May
178.	” ”	„ conglomeratus	8 June	22 June.
179.	” ”	„ obtusifolius	8 June	19 June.
180.	” ”	” ”	8 June	19 June.
181.	” ”	„ hydrolapathum	8 June	19 June.
334.	” ”	” ”	9 May	1 June.
182.	” ”	Rheum officinale	8 June	19 June.
183.	” ”	” ”	8 June	19 June.
148.	Æcidium Rumicis	Phragmitis communis	27 May	4 June.
166.	” ”	” ”	3 June	12 June.
172.	” ”	” ”	7 June	—
188.	” ”	” ”	16 June	10 July.
189.	” ”	” ”	16 June	10 July.
208.	” ”	” ”	2 July	20 July.
209.	” ”	” ”	2 July	30 July.
137.	Puccinia phragmitis	Ranunculus repens	18 May	—
138.	” ”	” ”	18 May	—
142.	” ”	” ficaria	20 May	—
346.	” ”	Rumex obtusifolius	16 May	25 May.
347.	” ”	” acetosa	16 May	—
177.	” ”	” ”	8 June	—
139.	” Magnusiana	” ”	17 May	—
179.	” ”	” ”	5 June	—
206.	” ”	” ”	28 June	—
323.	” ”	” ”	26 April	—
360.	” ”	Ranunculus acris	18 May	—
361.	” ”	” ficaria	18 May	—
359.	” ”	„ auricomus	18 May	—
362.	” ”	Berberis vulgaris	18 May	—

Uromyces dactylidis, Otth.—In 1861 Otth[1] described this Uromyces as occurring upon Dactylis glomerata accompanied by its uredospores. He describes the latter, but makes no allusion to their being associated with paraphyses, while upon the contrary, in another part of the same communication,[2] he describes an Epitea on Dactylis with "colourless, clavate, rather short epiphyses." In 1873 Schröter discovered that U. dactylidis has its æcidiospores upon Ranunculus bulbosus. In 1878 he states[3] that the æcidiospores occur not only on R. bulbosus, but also upon R. repens, L.; R. acris, L.; R. polyanthemos, L. Winter,[4] more recently, while giving the same æcidial host plants, states that the Uromyces occurs not only upon Dactylis glomerata, but also upon Poa nemoralis, L.; Festuca elatior, L., and Avena elatior, L.

Both these last-named authors consider the uredospores of the Dactylidis to be characterised by the possession of capitate paraphyses. Near King's Lynn Uromyces dactylidis occurs in one locality sufficiently near for me to obtain material for experiment and also to watch its growth as it occurs naturally.

Seven attempts made to produce the Uromyces upon Dactylis from the spores of the Æcidium in R. repens uniformly failed (29, 30, 119, 122, 131, 153, 154), and conversely, five attempts to produce the Æcidia upon R. repens from the teleutospores of the Uromyces also failed (118, 244, 254, 270, 290). The æcidiospores applied to Poa nemoralis (143) also produced no effect. But when the germinating teleutospores of this Uromyces were placed upon R. bulbosus they invariably gave rise to the Æcidia (248, 269). In order to see whether this fungus had its Æcidia upon any other of the commoner species of Ranunculus duplicated experiments were performed on R. acris (250, 271), R. ficaria (251, 255, 272), and

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[1] Otth, in 'Mittheilungen der Naturf. Gesselschaft,' Berne, 1861, p. 85.

[2] Otth, loc. cit., p. 81.

[3] Schröter, in 'Cohn's Beiträge,' Band iii, pp. 58, 59.

[4] Winter, 'Rabenhorst's Kryptogamen Flora,' 1881, p. 162.

R. auricomus (252, 273), but with no result. Hence it appears that Uromyces dactylidis has its æcidiospores upon R. bulbosus only, and not upon R. repens or acris.

Spores from the Æcidia on R. bulbosus were placed upon Dactylis glomerata (279, 289, 298), where they in all cases gave rise to a Uredo followed by the Uromyces dactylidis. Æcidiospores of this Æcidium placed upon Poa pratensis (299) and P. amma (300) gave no result. These last two cultures were duplicated with expt. 298.

In no case, however, in which the Uredo was produced upon Dactylis could I find the least trace of any paraphyses, nor could any be found upon the Dactylis uredo, as it occurs naturally here. The question, therefore, presents itself, Have Dr. Schröter and myself the same fungus in view? It is very unlikely that there should be two Uromyces upon Dactylis both having their Æcidia upon R. repens. Personally, I rather incline to the belief, and it is only a belief which subsequent observation must confirm or disprove, that these paraphyses are found in certain conditions of the Uredo and not in others; that in other words, their value as a specific character is not of vital importance. But what these conditions are which favour the development of paraphyses, I am unable, at present at any rate, to say. Just as I was unable to discover any difference externally between the two Æcidia upon R. repens, so am I unable to point out any anatomical differences between the two Æcidia on R. bulbosus, namely, that of Uromyces dactylidis and Puccinia Magnusiana. Physiologically, however, they are distinct enough.

No. of Expt.	Infected Material.	Plant Infected.	Date of	
			Infection.	1st Result.
248.	Uromyces dactylidis	Ranunculus bulbosus	2 Feb.	6 Mar.
269.	„ „	„ „	5 Mar.	26 Mar.
279.	Æcidium Ranunculi bulbosi	Dactylis glomerata	17 Mar.	25 Apr.
289.	„ „	„ „	7 Apr.	20 Apr.
298.	„ „	„ „	9 Apr.	20 May.
29.	„ Ranunculi repentis	„ „	13 May	—
30.	„ „	„ „	13 May	—
119.	„ „	„ „	28 Apr.	—
122.	„ „	„ „	28 Apr.	—
131.	„ „	„ „	2 May	—
153.	„ „	„ „	31 May	—
154.	„ „	„ „	31 May	—
118.	Uromyces dactylidis	Ranunculus repens	28 Apr.	—
249.	„ „	„ „	2 Feb.	—
254.	„ „	„ „	8 Feb.	—
270.	„ „	„ „	5 Mar.	—
290.	„ „	„ „	7 Apr.	—
143.	Æcidium Ranunculi repentis	Poa nemoralis	2 May	—
250.	Uromyces dactylidis	Ranunculus acris	2 Feb.	—
271.	„ „	„ „	5 Mar.	—
251.	„ „	„ ficaria	2 Feb.	—
255.	„ „	„ „	8 Feb.	—
272.	„ „	„ „	5 Mar.	—
252.	„ „	„ auricomus	2 Feb.	—
273.	„ „	„ „	5 Mar.	—
299.	Æcidium Ranunculi bulbosi	Poa pratensis	9 Apr.	—
300.	„ „	„ trivialis	9 Apr.	—

Puccinia perplexans, n. sp.—In the spring of this year I found in two places near King's Lynn upon Alopecurus pratensis, L., Avena elatior, L., and upon some blades of grass which I believe belonged to one of the Poæ, the exact species of which I was unable to determine, an abundant golden yellow Uredo, the spores of which were freely mixed with well-developed capitate paraphyses. Naturally the conclusion was arrived at that here was the Uredo with paraphyses, which Winter and Schröter have associated Uromyces dactylidis. The localities were from time to time revisited, but instead of finding the teleutospores of this paraphysed Uredo to be a Uromyces they were found to be those of a Puccinia. Further search was rewarded by gathering the last year's teleutospores sparingly upon the Poa, but abundantly upon the other two grasses. These Puccinia spores germinated well, and were used in the following experiments. In both localities above referred to numerous plants of Ranunculus acris were found in close proximity to the grasses affected with the Æcidium. The germinating teleutospores from the last year's Puccinia from the Poa (?) Avena elatior and Alopecurus were applied to R. acris (373, 381, 382, 383, 388, 389), and in every instance the Æcidium was produced. Here, then, was quite an unexpected discovery, that instead of the Æcidium on R. acris being connected with a Uromyces at all, it was connected with a Puccinia. Conversely the æcidiospores in question were placed upon Alopecurus (401, 402, 404) and Avena elatior (405), with the result of giving rise to a Uredo, followed in due course by the Puccinia. This Uredo, however, strange to say, was never once accompanied by any paraphyses at all. This puzzled me very much, for the paraphysed Uredo as it occurred naturally was always accompanied by the Puccinia, but by culture the result was invariably as above stated. The possibility of this Puccinia giving rise to a paraphysed Uredo upon some other graminacious host suggested itself. The æcidiospores from Ranunculus acris were, therefore, applied to Poa trivialis (364), P. nemoralis (367), P. pratensis (365, 366), P. compressa (?) (378), Dactylis glomerata (379), Lolium perenne (377, 403), upon all of which paraphysed uredospores are known to occur, but in every case without any result.

Ranunculus acris was infected with the germinating teleutospores of Uromyces dactylidis (250, 271) but with no success, as was also the case when P. Magnusiana (360) was employed. Puccinia perplexans bears a strong anatomical resemblance to P. rubigo-vera, the most obvious difference being that the last-named species has its teleutospores surrounded by a bed of dark brown paraphyses. In point of fact

I have previously mistaken these two Puccinia the one for the other. P. perplexans upon Lycopsis arvensis (311, 312, 326), Symphytum officinale (314, 329, 330), Borago officinale (327), and Pulmonaria officinale (328) gave no result. The same was the case when Ribes grossularia (371) and Lonicera periclymenum (313, 317) were infected with it.

Puccinia perplexans may be thus described—

I. Æcidiospores = Æcidium Ranunculi acridis.—Spores, 20 to 25 μ. in diameter, rather more orange in colour than those of the other Ranunculi Æcidia, otherwise not distinguishable.

II. Uredospores.—Sori rubrotund elliptical, but mostly linear. On both surfaces of the leaves, especially on the upper, scattered but sometimes confluent, soon naked golden yellow. Spores, globose, oval or ovate, orange, finely echinulate 20 to 25 μ. wide by 30 to 35 μ. long. With or without capitate paraphyses.

III. Teleutospores.—Sori small, almost black, punctiform, linear, or elliptico-elongate, covered by the epidermis, often clustered and confluent. Spores very irregular in form and size. Clavate, oblong, or subfusiform on very short pedicels, apex sometimes thickened, sometimes not; upper cell rounded, truncate, or attenuated, often obliquely; lower cell generally somewhat cuneiform, central constriction slight or absent. Epispore pale clear brown, often apparently coarsely granular, 40 to 60 μ. long by 10 to 12 μ. wide.

I. On Ranunculus acris. II. and III. On Alopecurus pratensis, Avena elatior and Poa sp.? Near King's Lynn. May and June, 1884.

No. of Expt.	Infecting Material.	Plant Infected.	Date of Infection.	Date of 1st Result.
373.	Puccinia perplexans	Ranunculus acris	23 May	9 June.
381.	" "	" "	29 May	9 June.
382.	" "	" "	29 May	9 June.
383.	" "	" "	29 May	12 June.
388.	" "	" "	31 May	9 June.
389.	" "	" "	31 May	9 June.
401.	Æcidium Ranunculi acridis	Alopecurus pratensum	13 June	27 June.
402.	" "	" "	13 June	28 June.
404.	" "	" "	16 June	30 June.
405.	" "	Avena elatior	1 July	20 July.
364.	" "	Poa trivialis	19 May	—
367.	" "	" nemoralis	19 May	—
365.	" "	" pratensis	19 May	—
366.	" "	" "	19 May	—
378.	" "	" compressa (?)	28 May	—
379.	" "	Dactylis glomerata	28 May	—
377.	" "	Lolium perenne	28 May	—
403.	" "	" "	13 June	—
250.	Uromyces dactylis	Ranunculus acris	2 Feb.	—
271.	" "	" "	5 Mar.	—
360.	Puccinia Magnusiana	" "	18 May	—
311.	" perplexans	Lycopsis arvensis	23 Apr.	—
312.	" "	" "	23 Apr.	—
326.	"	" "	5 May	—
314.	"	Symphytum officinale	23 Apr.	—
329.	" "	" "	5 May	—
330.	" "	" "	5 May	—
327.	" "	Borrago officinalis	5 May	—
328.	" "	Pulmonaria officinalis	5 May	—
371.	" "	Ribes grossularia	23 May	—
313.	" "	Lonicera periclymenum	23 Apr.	—
372.	" "	" "	23 May	—

Puccinia Schœleriana, n. sp.

For many years past I have found on North Wootton Heath, near King's Lynn, an Æcidium on Senecio Jacobæa,

L. This Æcidium is far from common in Great Britain, but in the spring of 1882 I met with it again at Skegness, Lincolnshire. It has been hitherto regarded either as a spore form of Puccinia compositarum, Mart., or of P. Senecionis, Desm. In neither of the above localities was the Æcidium accompanied by any Uredo or teleutospores upon the same host plant. The North Wootton Station has been examined with this point in view repeatedly, and at all seasons of the year. Growing in company with the Senecio, both in Norfolk and Lincolnshire, was, amongst other plants, Carex arenaria, L. In 1882 I noticed upon this Carex a Puccinia occurred on those plants which grew in the vicinity of the Æcidium-affected Seneciones, but not elsewhere. A series of experimental cultures were consequently undertaken, 1883-4, with the object of elucidation of the life-history of the Puccinia in question. There are, as is already known, several well-marked species of Puccinia which occur upon various carices, of these P. carices, Schum.; P. limosæ, Mag.; P. sylvaticæ, Schröt., and P. dioica Mag., have had their life-histories worked out; whereas P. microsora, Körn; P. caricicola, Fcke.; and P. vulpina, Schröt. have not. The only species with which the Puccinia on P. arenaria can be compared is P. dioica, Mag. I therefore sent specimens of my plant to Dr. Magnus, who at once pointed out the difference between the teleutospores of the two Puccinia. In P. dioica the summits of the teleutospores are not only much more thickened, but also generally prolonged upwards into a conical point. The uredospores of P. dioica, too, are described by Dr. Magnus[1] as being similar to those of P. caricis, Schum. Further, Rostrup[2] has, to say the least, pointed out the strong presumptive evidence that exists that Puccinia dioica has its æcidiospores upon Carduus palustris, L.; arvensis, L., and lanceolatus, L. It occurred to me that as Puccinia caricis, Schum., is our commonest carex infesting Puccinia in this country, C. Schœleriana might only be a variety of it occurring upon C. arenaria. The following duplicated cultures were therefore made.

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[1] Winter, 'Rabenhorst's Kryptogamen Flora,' 1881, vol. i, p. 182.

[2] Rostrup, loc. cit., p. 17 and p. v.

a. A quantity of P. Schœleriana was germinated in water in a watch-glass. This was divided into two parts, one of which was applied to a young plant of Senecio Jacobæa (260), and the other to a plant of Urtica dioica (261). The Senecio became affected with the Æcidium, but the Urtica did not.

b. Conversely, a quantity of P. caricis was germinated in water in a watch-glass, and divided into two parts, one of which was placed on a plant of Urtica dioica (258), and the other upon a Senecio (259). The Urtica became affected with the Æcidium, the Senecio did not. The spores of Æcidium Jacobææ applied to Carex arenaria gave rise to the Uredo (199, 388, 389). The teleutospores of Puccinia Schœleriana in seven separate cultures in every instance produced the Æcidium upon Senecio Jacobæa (260, 285, 291, 292, 293, 294, 447).

The Puccinia in question it is proposed to call Schœleriana after Schœler,[1] the Danish schoolmaster, who lived at the beginning of the present century in the village of Hammel, near Aarhuus, where he, by careful observation of what happened in nature, came to the conclusion that the yellow fungus on barberry has some connection with the rust on oats. He began these investigations in 1807, and continued them for some years.

In 1816 Schœler applied the "yellow dust" of the barberry fungus to some healthy rye plants, which were still moist with dew, and found the latter had, in the course of some few days, become badly affected with rust; "while at the same time not one rusty plant could be found anywhere else in the whole rye field." Schœler was also aware of the fact that rye became affected with rust without the intervention of the barberry.

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[1] Shœler, "Berberissens Skudelige Indflydelse pa Sæden," 'Landækommiske Tidender,' 1818, part viii, p. 289.

Puccinia Schœleriana, n. sp.

I. Æcidiospores (Æcidium Jacobææ, Grev., 'Flor. Edin.,' p. 445), Æcidia in circular clusters, mostly upon the under surface of the radical leaves; cups with reflexed torn white edges; spermogonia upon the corresponding upper surface of the affected leaves; spores rounded, yellow, finely echinulate; 15μ to 20μ in diameter.

II. Uredospores upon yellow discoloured spots; sori elongate or rubrotund, surrounded by the ruptured epidermis; generally hypophyllous spores, subglobose or ovate, yellowish brown, rough; 25μ to 30μ long by 14μ to 20μ wide.

III. Teleutospores—Sori erumpent, oblong or elongate, large, prominent, almost black; hypophyllous naked, surrounded by the ruptured epidermis; spores on long, firm pedicels, slightly constricted; upper cell subglobose, ovate, or attenuated upwards; apex much thickened, rounded, or pointed; lower cell cuneiform, often paler than the upper; rich brown, smooth; 60μ to 80μ long by 15μ to 20μ wide.

No. of Expt.	Infecting Material.	Plant Infected.	Date of	
			Infection.	1st Result
199.	Æcidium Jacobææ	Carex arenaria	21 June	15 July.
388.	„ „	„ „	31 May	12 June.
389.	„ „	„ „	31 May	20 June.
258.	Puccinia caricis	Urtica dioica	16 Feb.	11 Mar.
259.	„ „	Senecio Jacobææ	16 Feb.	—
260.	„ Schœleriana	„ „	17 Feb.	15 Mar.
261.	„ „	Urtica dioica	17 Feb.	—
285.	„ „	Senecio Jacobææ	6 Apr.	30 Apr.
291.	„ „	„ „	6 Apr.	30 Apr.
292.	„ „	„ „	6 Apr.	30 Apr.
293.	„ „	„ „	6 Apr.	30 Apr.
294.	„ „	„ „	6 Apr.	30 Apr.
447.	„ „	„ „	15 Sept.	26 Sept.

Conclusions.—From the experimental cultures above it appears—

1. That Ranunculus repens is the host plant upon which both Uromyces poæ and Puccinia Magnusiana have their æcidiospores.

2. That these two Æcidia are not to be distinguished from each other anatomically.

3. That Ranunculus bulbosus is the host plant upon which both Uromyces dactylidis and Puccinia Magnusiana have their æcidiospores, which in like manner are anatomically indistinguishable.

4. That Uromyces poæ has its æcidiospores upon Ranunculus ficaria and R. repens.

5. That Uromyces dactylidis in this district has its Uredo without capitate paraphyses.

6. That the Æcidium upon Ranunculus acris belongs to the life cycle of Puccinia perplexans, a Puccinia the teleutospores of which occur upon Alopecurus pratensis, Avena elatior, and Poa sp. (?), bearing a close resemblance to those of P. rubigo-vera, but wanting the dark paraphyses of the latter species.

7. That the uredospores of P. perplexans are sometimes mixed with capitate paraphyses and sometimes without them.

8. That Puccinia phragmitis has its æcidiospores upon Rumex hydrolapathum, R. obtusifolius, L.; R. crispus, L.; R. conglomeratus, Mur., and Rheum officinale.

9. That P. Magnusiana has its æcidiospores upon Ranunculus repens and R. bulbosus.

10. That the Æcidium upon Rumex acetosa is neither connected with P. Magnusiana nor with P. phragmitis.

11. That the Æcidium on Senecio Jacobæa belongs to the cycle of a Carex inhabiting Puccinia—P. Schœleriana.

	ÆCIDIOSPORES.	UREDO AND TELEUTOSPORES.
Uromyces poæ, Rhb.	Ranunculus repens „ ficaria	Poa trivialis. „ pratensis.
Uromyces dactylidis, Otth.	Ranunculus bulbosa	Dactylis glomerata.
Puccinia Magnusiana, Korn.	Ranunculus bulbosa „ repens	Phragmitis communis.
Puccinia perplexans, Plow.	Ranunculus acris	Avena elatior. Alopecurus pratenses. Poa sp.?
Puccinia phragmitis, D. C.	Rumex obtusifolius „ hydrolapathum „ crispus „ conglomeratus Rheum officinale	Phragmitis communis.
Puccinia Schœleriana Plow.	Senecio Jacobæa	Carex arenaria.